Electrical and electronics engineers design and test equipment used by other scientists.

and electronic equipment. Some of this equipment includes power generating, controlling, and transmission devices used by electric utilities; electric motors, machinery controls, lighting, and wiring in buildings, automobiles, and aircraft; and in radar and navigation systems, computer and office equipment, and broadcast and communications systems.

Electrical and electronics engineers specialize in different areas such as power generation, transmission, and distribution; communications; computer electronics; and electrical equipment manufacturing—or a subdivision of these areas—industrial robot control systems or aviation electronics, for example. Electrical and electronics engineers design new products, write performance requirements, and develop maintenance schedules. They also test equipment, solve operating problems, and estimate the time and cost of engineering projects. (See the statement on computer systems analysts, engineers, and scientists elsewhere in the *Handbook*.)

Employment

Electrical and electronics engineers held about 357,000 jobs in 1998, making it the largest branch of engineering. Most jobs were in engineering and business consulting firms, government agencies, and manufacturers of electrical and electronic equipment, industrial machinery, and professional and scientific instruments. Communications and utilities firms, manufacturers of aircraft and guided missiles, and computer and data processing services firms accounted for most of the remaining jobs.

California, Texas, New York, and New Jersey—states with many large electronics firms—employ over one-third of all electrical and electronics engineers.

Job Outlook

Electrical and electronics engineering graduates should have favorable job opportunities. The number of job openings resulting from employment growth and the need to replace electrical engineers who transfer to other occupations or leave the labor force is expected to be in rough balance with the supply of graduates. Employment of electrical and electronics engineers is expected to grow faster than the average for all occupations through 2008.

Projected job growth stems largely from increased demand for electrical and electronic goods, including computers and communications equipment. The need for electronics manufacturers to invest heavily in research and development to remain competitive and have a scientific edge will provide openings for graduates who have learned the latest technologies. Opportunities for electronics engineers in defense-related firms should improve as aircraft and weapons systems are upgraded with improved navigation, control, guidance, and targeting systems. However, job growth is expected to be fastest in services industries—particularly consulting firms that provide electronic engineering expertise.

Continuing education is important for electrical and electronics engineers. Engineers who fail to keep up with the rapid changes in technology risk technological obsolescence, which makes them more susceptible to layoffs or, at a minimum, more likely to be passed over for advancement.

Earnings

Median annual earnings of electrical and electronics engineers were $62,660 in 1998. The middle 50 percent earned between $47,080 and $80,160. The lowest 10 percent earned less than $38,470 and the highest 10 percent earned more than $91,490. Median annual earnings in the industries employing the largest numbers of electrical and electronics engineers in 1997 were:

Federal government	$68,000
Computer and office equipment	67,100
Electronic components and accessories	59,900
Communications equipment	59,400
Engineering and architectural services	58,900

According to a 1999 salary survey by the National Association of Colleges and Employers, bachelor's degree candidates in electrical and electronics engineering received starting offers averaging about $45,200 a year; master's degree candidates, $57,200; and Ph.D. candidates, $70,800.

(See introduction to the section on engineers for information on working conditions, training requirements, and sources of additional information.)

Industrial Engineers, Except Safety Engineers

(O*NET 22128)

Nature of the Work

Industrial engineers determine the most effective ways for an organization to use the basic factors of production—people, machines, materials, information, and energy—to make a product or provide a service. They are the bridge between management goals and operational performance. They are more concerned with increasing productivity through the management of people, methods of business organization, and technology than are engineers in other specialties, who generally work more with products or processes.

To solve organizational, production, and related problems most efficiently, industrial engineers carefully study the product and its requirements, use mathematical methods such as operations research to meet those requirements, and design manufacturing and information systems. They develop management control systems to aid in financial planning and cost analysis, design production planning and control systems to coordinate activities and control product quality, and design or improve systems for the physical distribution of goods and services. Industrial engineers determine which plant location has the best combination of raw materials availability, transportation, and costs. They also develop wage and salary administration systems and job evaluation programs. Many industrial engineers move into management positions because the work is closely related.

Employment

Industrial engineers held about 126,000 jobs in 1998. Over 70 percent of these jobs were in manufacturing industries. Because their skills can be used in almost any type of organization, industrial engineers are more widely distributed among manufacturing industries than other engineers.

Industrial engineers often use computers to improve products and services.

Their skills can be readily applied outside manufacturing as well. Some work in engineering and management services, utilities, and business services; others work for government agencies or as independent consultants.

Job Outlook
Employment of industrial engineers is expected to grow about as fast as the average for all occupations through 2008, reflecting industrial growth, more complex business operations, and greater use of automation in factories and offices. Because the main function of an industrial engineer is to make a higher quality product as efficiently as possible, their services should be in demand in the manufacturing sector as firms seek to reduce costs and increase productivity through scientific management. In addition to job growth, openings will result from the need to replace industrial engineers who transfer to other occupations or leave the labor force.

Earnings
Median annual earnings of industrial engineers were $52,610 in 1998. The middle 50 percent earned between $42,690 and $73,870. The lowest 10 percent earned less than $35,250 and the highest 10 percent earned more than $87,010. Median annual earnings in the manufacturing industries employing the largest numbers of industrial engineers in 1997 were:

Motor vehicles and equipment	$58,900
Electronic components and accessories	48,800
Aircraft and parts	44,100

According to a 1999 salary survey by the National Association of Colleges and Employers, bachelor's degree candidates in industrial engineering received starting offers averaging about $43,100 a year; master's degree candidates, $49,900.

(See introduction to the section on engineers for information on working conditions, training requirements, and sources of additional information.)

Materials Engineers

(O*NET 22105A, 22105B, 22105C, and 22105D)

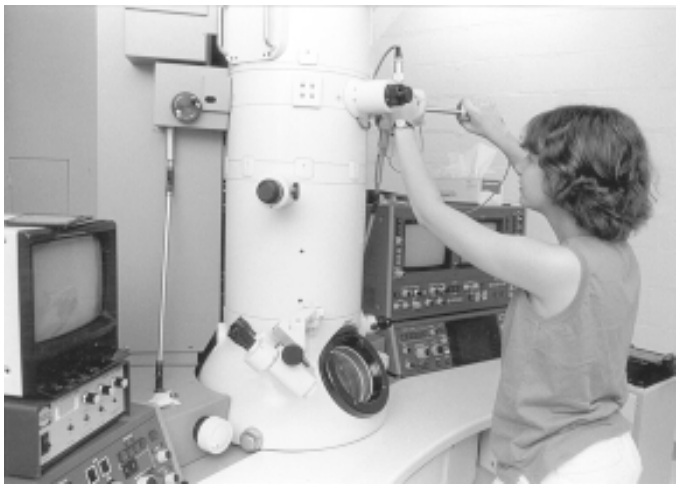
Nature of the Work
Materials engineers manipulate the atomic and molecular structure of substances to create products such as computer chips and television screens to golf clubs and snow skis. They work with metals, ceramics, plastics, semiconductors, and combinations of materials called composites to create new materials that meet certain mechanical, electrical, and chemical requirements. They also test and evaluate existing materials for new applications. Materials engineers specializing in metals can be considered *metallurgical engineers*, while those specializing in ceramics can be considered *ceramic engineers*.

Most metallurgical engineers work in one of the three main branches of metallurgy—extractive or chemical, physical, and mechanical or process. Extractive metallurgists are concerned with removing metals from ores and refining and alloying them to obtain useful metal. Physical metallurgists study the nature, structure, and physical properties of metals and their alloys, and methods of processing them into final products. Mechanical metallurgists develop and improve metalworking processes such as casting, forging, rolling, and drawing.

Ceramic engineers develop new ceramic materials and methods for making ceramic materials into useful products. Ceramics include all nonmetallic, inorganic materials that generally require high temperatures in their processing. Ceramic engineers work on products as diverse as glassware, automobile and aircraft engine components, fiber-optic communication lines, tile, and electric insulators.

Employment
Materials engineers held about 20,000 jobs in 1998. Because materials are building blocks for other goods, materials engineers are widely distributed among manufacturing industries. In fact, over half of materials engineers worked in metal-producing and processing; electronic and other electrical equipment; transportation equipment; industrial machinery and equipment; and stone, clay, and glass products manufacturing. They also worked in services industries such as engineering and management, business, and health services. Most remaining materials engineers worked for Federal and State governments.

Job Outlook
Employment of materials engineers is expected to grow more slowly than the average for all occupations through 2008. Many of the manufacturing industries in which materials engineers are concentrated—such as primary metals; industrial machinery and equipment; and stone, clay, and glass products—are expected to experience declines in employment. As firms outsource their materials engineering needs, however, employment growth is expected in many services industries including research and testing, personnel



Materials engineers analyze the physical and chemical characteristics of substances.